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Energy-Efficient Window Treatments

Cooperative Extension South Dakota State University

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FS 776

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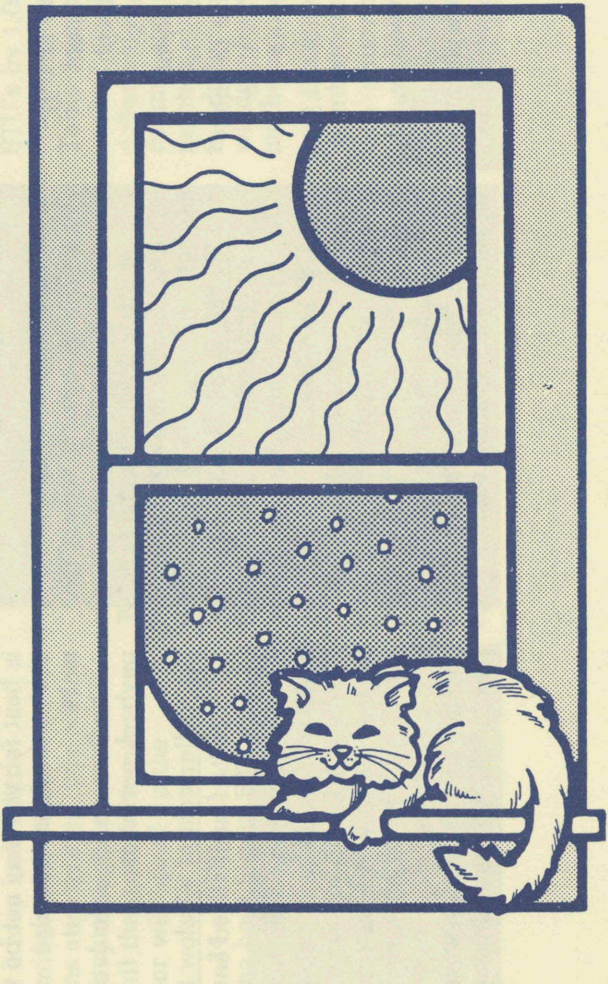

COOPERATIVE EXTENSION SERVICE
SOUTH DAKOTA STATE UNIVERSITY
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Energy-efficient window treatments

The first windows in primitive dwellings thousands of years ago were just holes in the walls. While windows in homes today are not animal hides stretched over bare openings, the basic purpose of the window has remained the same. Windows still provide a source of light, ventilation, and a view.

As home heating costs have risen in the last few years, many homeowners have insulated the walls and ceilings of their homes. This creates some interesting problems with windows. The insulated walls are much more resistant to heat loss than even the best windows.

Windows are once again a kind of "hole" in the wall—an easy place for heat to escape.

In addition, weathertight and insulated homes may have more problems with condensation. Condensation on a window occurs when warm, moist room air comes in contact with the cool glass surface. When the air is cooled, it loses some of its ability to hold moisture, the excess moisture is deposited on the glass, and the vapor becomes droplets. Over time, too much condensation can lead to damage to the window sill and surrounding areas.

This publication discusses how heat is lost at windows, how to counteract that heat loss, how to calculate heat loss (and cost of that lost heat), and how to figure savings if you change the window treatment.

How windows lose heat

Heat is lost at windows in four ways: infiltration, conduction, convection, and radiation.

Infiltration describes air leaks and drafts around windows. Leaks occur both around the window unit itself as well as the window frame.

Conduction occurs when a warm object (the window glass) gives up its heat to a cooler object or gas (the outside air). In this form of heat loss, the heat travels directly through the glass, rather than around the glass, as in infiltration.

Glass provides very little resistance to heat lost by conduction. Another way to explain this is that glass is a poor insulator but an excellent conductor of heat. The greater the temperature difference between the inside and outside of the house, the greater the rate of heat loss through conduction.

Convection happens when gases (air) expand and move upward as they are warmed or become denser and move downward as they cool.

Warm room air passes over the cooler glass surface and warms it. Heat from the room air is lost to the glass, which in turn loses it to the cooler outside air. The room air which has just passed over the window is cooled and sinks toward the floor, creating cool drafts.

A "chimney" effect occurs at the window when draperies are closed and the warm air enters at either the top or bottom of the drapery, moves across the glass, and exits as cool air.

Radiation occurs when heat from a warm surface is given off to the air and to other surfaces surrounding it. Sitting next to an uncovered window in winter can be very uncomfortable because your body warmth is given up to the cooler glass surface.

An energy efficient window

It's without holes and cracks.

Eliminating holes and cracks is the most effective way to cut down on infiltration heat losses. Caulking and weatherstripping are the materials you need. Very old or poor quality windows which simply don't fit together well may need to be replaced with new windows. Caulking is used between fixed or stationary pieces of the window. Weatherstripping is used between moving parts or between a moving and a fixed part. For information on caulking and weatherstripping, refer to Fact Sheet (FS) 731.

It has a high R-value.

Raising the R-value of the window and window treatment is the way to reduce conduction heat losses. R-value is a measure of the material's resistance to heat flow. The higher the R-value, the better the insulation.

Adding layers of glass or plastic is one possibility. Other ideas for increasing the R-value of the total window with insulating window treatments are in FS 777, Improving the energy-efficiency of draperies, FS 778, Cornices, valances, and lambrequins, FS 779, Insulated Roman shades, and FS 780, Insulated shutters and panels.

It's snug fitting.

Snug-fitting window treatments are the key to cutting down on heat losses by convection. They can also cut losses by conduction and radiation.

Attaching the window treatment to the sill and frame and providing a snug fit at the top with ceiling mounted rods and cornices are a few of the possibilities. For more specific ideas, refer to FS 777, Improving the energy-efficiency of draperies, and FS 778, Cornices, valances and lambrequins.

It provides a reflective layer.

Such a window treatment reflects heat lost by radiation back into the room. A reflective layer to the outside can also help keep out unwanted summer sun.

Table 1. Heating degree days for South Dakota counties. (1 HDD = 1°F difference between inside and outside temperatures for a 24-hr period) Source: AGNET HOUSE printouts.

Aurora	7207	Faulk	8191	Meade	7574
Beadle	8081	Grant	8249	Mellette	6816
Bennett	7068	Gregory	7082	Miner	7917
Bon Homme	7028	Haakon	7383	Minnehaha	7809
Brookings	8175	Hamlin	8479	Moody	8060
Brown	8488	Hand	7919	Pennington	7118
Brule	7226	Hanson	7399	Perkins	8651
Butte	7378	Harding	8273	Potter	8060
Campbell	8772	Hughes	7365	Roberts	8219
Charles Mix	7059	Hutchinson	7244	Sanborn	7831
Clark	8456	Hyde	8014	Shannon	7178
Clay	6659	Jackson	7428	Spink	8100
Codington	8685	Jerauld	7508	Stanley	7618
Corson	8644	Jones	7034	Sully	7893
Custer	8999	Kingsbury	8099	Todd	6837
Davison	7358	Lake	8149	Tripp	6837
Day	8838	Lawrence	7094	Turner	7337
Deuel	8685	Lincoln	7328	Union	7181
Dewey	8306	Lyman	7412	Walworth	8133
Douglas	7156	McCook	7594	Yankton	7181
Edmunds	8630	McPherson	8761	Ziebach	7824
Fall River	6975	Marshall	8545		

It provides a vapor barrier. This cuts down on undesired moisture condensation on the window glass. A vapor barrier also adds to the comfort level of the room air by keeping the moisture in the air—not on the cool glass.

Calculate heat loss

The formula below is used to figure heat loss through any given "construction." A construction is a combination of layers of different materials. A window construction might consist of a storm window, an air-space, a window, an air-space, and a drapery.

It is the same formula used to calculate heat loss for a wall, ceiling, or floor.

While it may look a little complex, if you follow the directions step-by-step, you will find it easy enough to use. You can do all the math by hand; a calculator will speed up the process.

$$H = 24 \times HDD \times U \times FT^2$$

H is the heat loss in BTU's (A BTU or British Thermal Unit is a standard measure of heat) of the window.

The 24 represents 24 hours in one day.

HDD represents Heating Degree Days. Look up the HDD value for **your** county in Table 1.

U or U-value is the amount of heat energy, in BTU, transmitted by 1 square foot of a construction in an hour, when the temperature difference inside to outside is 1°F. This could also be written BTU/ft^2hr^oF.

In other words, the U-value represents the ability of the construction to let heat pass through it.

To obtain the U-value add all the R-values for typical window materials in Table 2. After you have added the R-values, divide them into 1. This gives you the U-value. The mathematical formula for U-value looks like this:

$$U = \frac{1}{(R_1 + R_2 + R_3 \ldots)}$$

FT^2 represents the square feet of surface area of the window. To obtain square feet, multiply length of the window times the width. Hint: if you measure the window in inches, multiply length x width to obtain the total square inches. Then divide by 144 to obtain the square feet.

To work the heat loss equation, first find the values for **your** window and location for HDD, U and FT^2. Then work the equation. It gives you a very close estimate of heat loss.

EXAMPLE: A family in Brown county wants to know how much energy they are losing from the picture window in their living room. The window is double-pane glass with ¼-inch airspace between the glass. The window is presently covered with loose draperies. The window measures 48 x 60 inches.

HDD = 8488

$$U = \frac{1}{(R_1 + R_2)}$$

$$= \frac{1}{(1.5 + .09)}$$

(double pane + loose drapery)

$$= \frac{1}{1.59}$$

$$= .6289$$

$$FT^2 = \frac{48 \times 60 \text{ inches}}{144 \text{ inches}}$$

(window size)

$$= 20$$

Putting these values into the heat loss equation:

$$H = 24 \times HDD \times U \times FT^2$$

$$H = 24 \times 8488 \times .6289 \times 20$$

$$H = 2{,}562{,}289.54$$

The family is losing 2,562,289.54 BTU's of energy out their living room window each year.

Calculate cost of heat loss

Once you have determined the heat loss in BTU's, it is possible to figure the dollar cost.

First divide the heat loss in BTU's by 1,000,000. Then, look up the type of fuel you use in Table 3 or use your own local costs if available. Take the dollar value in the right-hand column and multiply it by the number above. This will give you the dollar cost of heating the window for one year. This is the mathematical equation:

$$\$ = \frac{H}{1{,}000{,}000} \times \text{Cost for } 10^6 \text{ BTU usable heat}$$

EXAMPLE: The Brown county family's living room window loses 2,562,289.54 BTU's each year. They

Table 2. Data for use in calculations.

Materials (vertical panels)*	R-value
single pane flat glass[1]	.90
insulating glass-double pane[1]	
¼-inch air space	1.50
½-inch air space	2.0
storm windows[1]	
1 pane plus air space	2.0
insulating glass-triple pane[1]	
¼-inch air space	2.55
½-inch air space	3.22
air space[1]	
¾-inch to 4 inches deep	.90
fiberglass batts[2]	
1 inch thick	3.5
insulation board[2]	
½-inch thick	1.3
fiberfill batting[2] (5/8 inch thick per layer)	
1 layer	1.56
2 layers	3.12
3 layers	4.68
loose drapery[3]	.09
loose drapery with closed-top cornice[3]	.22
sealed-closed drapery, attached at sides and center and with closed-top cornice[3]	.54
pulled shade	.24
¼-inch plywood	.31
1-inch rigid foam insulation board[5]	
polyurethane	6.1
polystyrene (beadboard)	3.4
polystyrene (styrofoam)	3.8

*Superscripts refer to information sources listed at end of fact sheet.

want to know how much it costs them in dollars for this lost heat. They heat with natural gas.

$$\$ = \frac{2,562,289.54}{1,000,000} \times 4.28$$

$$= 2.5623 \times 4.28$$

$$= 10.97$$

It costs about $10.97 each year to heat the living room window alone.

The difference with an energy-efficient window treatment

To determine how much difference a more energy-efficient window treatment would make in your heating costs, you simply figure the heat loss and cost again, this time using the R-values for the particular window treatment you are considering. Pick up and add the basic R-values for your window glass, storm window, and any air spaces.

Then determine how much you can save by subtracting the cost of your desired window treatment from the cost of your present window heat loss.

Table 3. Cost of fuel (1980).

	Cost/ unit	Furnace efficiency	Cost for 10^6 BTU usable heat
Oil	85¢/gal	67%	$9.55
Gas	30¢/100 cu ft	70%(est)	4.28
Electric	5¢/Kwh	95% (baseboard)	15.40

EXAMPLE: The same Brown county family has decided that they want to improve the energy-efficiency of their window. They would like to use an insulated Roman shade, but first they want to know if they will really save money by putting up a Roman shade. They would like a shade with a medium amount of bulk, so they are planning to use two layers of fiberfill for insulation.

$$H = 24 \times HDD \times U \times FT^2$$

(Note: The only value that is different this time from the first time they calculated their heat loss is the U-value for the window and window treatments.)

$$U = \frac{1}{(1.5 + .9 + 3.12)}$$

(double pane + air space + fiberfill batting)

$$= \frac{1}{5.22}$$

$$= .1916$$

Putting this U-value into the heat loss equation:

$$H = 24 \times 8488 \times .1916 \times 20$$

$$H = 780,624.39$$

The window would only lose 780,624.39 BTU's each year with the Roman shade. Cost of the heat loss with the shade is figured in the same manner as figuring the original heat loss cost:

$$\$ = \frac{780,624,39}{1,000,000} \times 4.28$$

$$= .7806 \times 4.28$$

$$= 3.34$$

The cost to heat the Brown county family's living room window with an insulated Roman shade is about $3.34 each year. Subtracting this cost from the original heating costs will show how much money each year would be saved with the addition of the insulated Roman shade.

$10.97 original heating costs
−3.34 heating costs with insulated Roman shade

$ 7.63 saved each year by adding the insulated Roman shade.

Calculate payback period

Saving money with insulating window treatments is important. It is also very important that the cost to install the window treatment is paid back within a reasonable period of time.

What is a "reasonable period of time" for one family might be 2 years, for another 5.

The length of the payback period also is dependent upon how much the window treatment costs in the first place. If two windows of exactly the same size are located in a home, the homeowner might choose two different window treatments, especially if the windows were in different rooms. One treatment might cost twice as much as the other. If both saved the same amount of heat each year, it would still take twice as long to pay back the costs of installing the more expensive window treatment.

It is important to note here that the same window treatment won't be appropriate for every home or every room in the home. Variety adds spice to life! What is best for you may not be the choice that someone else would make.

The formula for calculating payback period is:

$$PB = \frac{\text{dollar cost of window treatment}}{\text{cost of heat saved each year}}$$

EXAMPLE: The Brown county family wants to know how long it will take them to save enough money on their heating bill to pay back the cost of putting in the insulating Roman shade.

To figure cost of the shade materials, refer to FS 779, Insulated Roman shades, for a materials list, and to Table 4 for a list of estimated costs. For a 20-square foot shade the following materials costs are estimated:

$2.00	fiberfill batting
1.00	plastic sheeting
5.80	lining fabric
4.60	face fabric
7.00	cord, tape, rings, board for mounting, nails
$20.40	total cost for shade and installation

Taking the total cost and dividing by the yearly savings will give the payback:

$$PB = \frac{20.40}{7.63}$$

$$PB = 2.67$$

The payback period for this particular insulated Roman shade is 2.67 years or about 2 years, 7 months.

Remember that payback is always figured on the basis of today's fuel costs. If fuel costs rise, the payback period will be shorter.

Table 4. Cost of some materials (1981). Cost may vary by brand and quality of materials selected.

Dacron batting	10¢/sq ft
plastic sheeting	5¢/sq ft
lining fabric (insulated) @$2.79/yard, 45 inches wide	29¢/sq ft
Face fabric (gingham) @ $2.19/yard, 45 inches wide	23¢/sq ft
Fusible web @ $.99/yard, 18 inches wide	22¢/sq ft
drapery fabric 45 inches wide	$4.00-$15.00/yd
Milium insulated lining 45 inches wide	$3.79/yd
window shades:	
plastic	40¢/sq ft
cloth	50¢/sq ft

Fact sheets in this series

FS 776, Energy-efficient window treatments
FS 777, Energy-efficient draperies
FS 778, Cornices and lambrequins
FS 779, Insulated Roman shades
FS 780, Insulated shutters and panels

For more information, contact Grace Backman, Extension housing specialist, SDSU. This fact sheet prepared by Mary Ann Sward, former housing specialist, with cooperation from Kathleen Parrott, University of Nebraska housing specialist.

Additional information was obtained from the following sources:
[1]ASHRAE. Handbook of fundamentals. 1977.
[2]Korda, Nancy and Susan Kummer for Wisconsin Energy Extension Service. What about windows? 1978.
[3]University of Georgia study.
[4]Anderson, Bruce. Solar energy fundamentals in building design. 1977.
[5]AGNET HOUSE, list of codes. 12/79.

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FS 776

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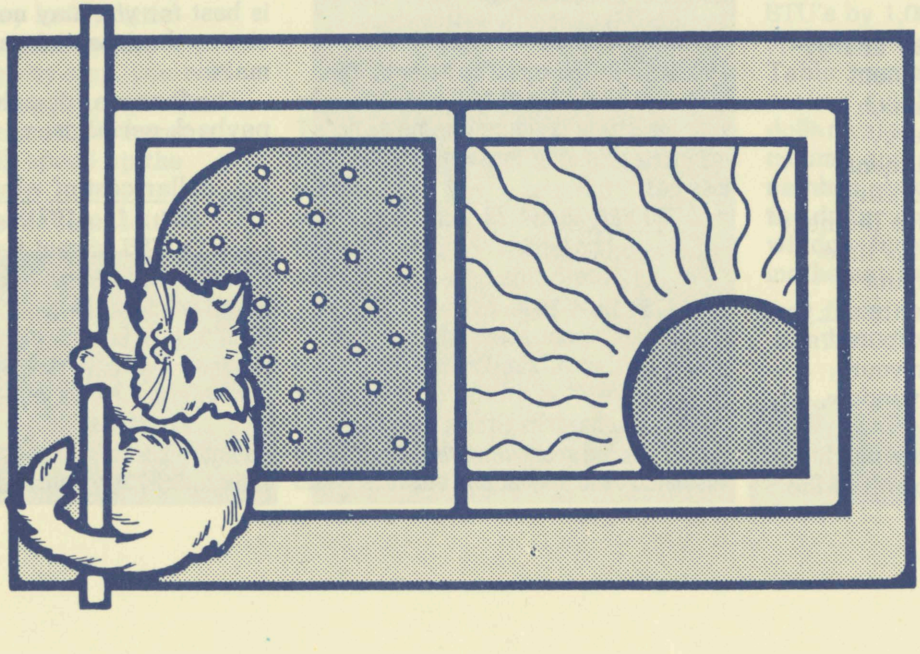

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